M. Turgot, the celebrated M. Lavoisier was appointed superintendant of the French national powder works, and with what success he executed the duties of his important commission the history of their subsequent naval campaigns have sufficiently evinced. The efforts of European chemists, seem to have been principally directed to the removal of the marine salt which the nitre of Spain and India contains in great quantities. In the nitre of Kentucky, I have never detected a particle of that salt, and I am confident, that if any is found in it, the proportion must be very inconsiderable indeed. The rock saltpetre I am persuaded, would, with very little refinement, make gun-powder capable of retaining its efficient properties during the longest voyages, as I have never discovered, in that species of nitre, the smallest tendency either to deliquescence or efflorescence.

It will be observed, that I have not in this paper, hazarded any opinion with regard to the formation of nitre in our sand rocks. I freely confess that I have no theory on that subject which is satisfactory to my own mind, I am even disposed to suspect, that our greatest chemists have still much to learn with regard to this salt, so valuable in time of peace, so indispensable in time of war.

No. XL.

An Essay on the vermilion colour of the blood, and on the different colours of the metallic oxides, with an application of these principles to the arts. By Samuel F. Conover M. D.

Read June 20th, 1806.

On the Vermilion colour of the blood.

THESE subjects have excited the attention of some of the most eminent philosophers of the last and present century, though little progress was made in the explanation of these phenomena, previously to the institution of the *pneumatic philosophy,* when truth burst forth upon mankind, dispelled the

errors of former ages, and rendered plain and easy the path to the temple of science.—The ancient philosophers, seem to have entertained very incorrect ideas of the cause of the *red* colour of the blood, and I believe it was very little understood, before the celebrated Priestley Lavoisier and Scheele discovered *oxiginous gas, or vital air;* since that memorable period, many and various have been the opinions adopted on the vermilion colour of the blood, and each one has had its votaries.

It has been proved by a variety of experiments made by these eminent chemists, that atmospheric air, is a mixture of oxigene and azotic gases, in the proportion of twenty-five parts of the former, and seventy-five parts of the latter. Priestley, Cigna, Hewson, Thouvenel and Beccaria, have made many experiments on the blood, and have all united in the opinion that its vermilion colour, should be attributed to the absorption of oxigene, by the blood, in its passage through the lungs during respiration. This doctrine sanctioned by such imposing names, influenced for a long time, physiologists and chemists to adopt it as the only true philosophy, which had ever been promulgated. The great Darwin, whose imagination was too transcendant to be imprisoned within the bounds of ordinary men, instituted a new theory of the vermilion colour of the blood, partly founded upon the foregoing principles, which nevertheless is infinitely more fanciful than philosophical; for he observes, "that during respiration, the blood imbibes the vital part of the air, called oxigene, through the membranes of the lungs; and that hence respiration may be aptly compared to a slow combustion.—As in combustion the oxigene of the atmosphere unites with some phlogistic or inflammable body, and forms an acid (as in the production of the vitriolic acid from sulphur, or carbonic acid from charcoal) giving out at the same time a quantity of the matter of heat, so in respiration, the oxigene of the air unites with the phlogistic part of the blood, and probably produces phosphoric or animal acid, changing the colour of the blood from a dark to a bright red."

Chaptal in his treatise on the blood, remarks that "the colour of the blood has been attributed to iron; that the blood

does not become coloured without the concourse of air, and that as *oxigene alone* is absorbed in respiration, it appears that the colour is owing to iron calcined by the pure air, and reduced to the state of a red oxide." This evidently, is advancing one step further towards the truth than the foregoing doctrines, nevertheless he has stopped short of explaining the true phenomenon, for it is very manifest that he has endeavoured to prove in all his experiments, that oxigene gas is nothing but *oxigene* and *caloric*. But, by the experiments of Mr. Berthollet, it appears, that "oxigene and light have great affinity, that light is susceptible of combining with it, and that it contributes along with caloric to change it into the state of gas." Mr. Fourcroy in his general system of chemistry, and particularly on the colouring part of the blood, has offered the following theory.

He says "it must be observed that there are two phosphates of this metal," alluding to iron, "the one white-grey, frequently of a pearly brilliancy, insoluble in water, soluble in the acids; and the other red, more or less brown, and less soluble in the acids; this is phosphate with excess of oxide of iron, and the other is saturated with its acid." "The white phosphate of iron is decomposed only in a partial manner by the caustic alkalis, which take from it only a part of its acid, and leave the salt with an excess of this base. It is in this state of phosphate supersaturated with iron, a state maintained by the presence of the soda, that this metal is dissolved in the blood, and in particular in its serum. The blood of all animals, when it is red, is coloured by the phosphate of iron," How far this theory corresponds with the laws of the affinities, and the experiments of eminent chemists, the following observations will shew. If the phosphorus in the blood has a greater attraction for the oxigene taken in during respiration than the iron, the phosphoric acid must consequently first take place, before the phosphate of iron can be produced. If we take for granted that the phosphoric acid is produced in the blood, the *soda* with which the blood abounds, having a greater affinity to phosphoric acid, than what iron has, the phosphate of *soda* must be the necessary result, and the iron would consequently be left free. For the experiments of Mr. Lavoi-

sier, and his tables of combinations of the phosphoric acids with salifiable bases in the order of affinity, clearly prove, the doctrine of Fourcroy to be highly chimerical.—Also Chaptal remarks "that *phosphorus* precipitates some metallic oxides from their solution in the metallic state; phosphoric acid is formed in this operation, which proves that the oxigene quits the metal to unite with the phosphorus," and that "phosphoric acid acts only on a small number of metallic substances." These arguments are sufficient to refute the theory of Mr. Fourcroy, without the assistance of any additional ones.

Mr. Davy, who has contributed much to the stock of chemical knowledge, denies that vital air is decomposed in respiration, and endeavours to maintain, that the disengaged carbonic acid and water, are constituent principles of venous blood, which are displaced by the vital air; for which the venous blood has a greater elective attraction, than for its constituent elements, water and carbonic acid.—He also denies the existence of caloric altogether, and says that oxigene gas consists of oxigene and light, which he has denominated phos-oxigene; from which he infers that in the process of respiration, the phos-oxigene combines with the venous blood in the lungs, and disengages the carbonic acid and aqueous gas from it, and further, that the vermilion colour of the blood, is produced by phos-oxigene combining with it in its intire state.—If it were a fact, that phos-oxigene combined with the blood in its *intire state*, the blood instead of assuming the vermilion colour, would in consequence of absorbing all the rays of light, take on the appearance of absolute blackness.—Hence his method of resolving the phenomenon of the red colour of the blood is inadmissible.

Mr Joseph Trent, who graduated in the University of Pennsylvania, A. D. 1800, observes that "light is a constituent of oxigene gas, and that it is to the disengagement and operation of this substance in respiration, that some of its phenomena ought, in part, to be attributed, more especially the vermilion colour of pulmonary blood."—I have endeavoured to give a fair and judicious exposition of the different doctrines on the vermilion colour of the blood, and shall now proceed to offer

for the consideration of this learned Society, my observations and arguments in favour of a new theory, predicated on the Newtonian and pneumatic philosophy, in explaining the subjects of this Essay.

From the experiments which I have made on *light*, and from those detailed by the great Newton and other celebrated philosophers, on which we may rely, it appears, that *light* is a mixture of seven different coloured rays, of different refrangibilities and reflexibilities, and that we are indebted to the sun for all the light we enjoy; that heat is a simple elementary body, and a necessary constituent of this planet; that oxigene gas is a compound of *light, heat,* and *oxigene,* and that oxigene is held in its gaseous state by the means of *caloric;* all of which have been proved by numerous experiments made by Berthollet, Davy*, and other eminent chemists, which being conceded, renders it unnecessary to detail them here.—It has also been proved beyond the possibility of doubt, by the experiments of the most respectable chemists, that the blood contains *iron.*—Hence when atmospheric air is taken into the lungs, the oxigene gas is absorbed by the blood in its passage through the lungs during respiration, and from the great affinity of oxigene to the iron in the blood, it unites with that metal, and the *red ray,* a constituent of oxigene gas (the most difficult of refrangibility) is absorbed at the same time by the iron and becomes fixed, which constitutes the red oxide of iron, and illustrates in a philosophical manner, the beautiful phenomenon of the vermilion colour of the blood; while the heat is set at liberty, and the other six constituent rays of light, either become fixed in the other parts of the blood, or are carried off in a latent state, by expiration; for it is an established principle in optics, "that some rays enter into the combination of bodies, while others are reflected, and this in proportion to the greater or less affinity of the several rays with these bodies."

According to the experiments of Mr. Davy, on the composition of the *nitrous oxide gas,* and its comparative influence

* With the exception that Mr. Davy makes to the existence of *caloric* altogether.—The first evidence of the existence of matter, is that, it has motion, all the experiments on heat, prove its momentum, and consequently it has attached to it all the properties of matter.

on the venous blood of animals, exposed to it, compared with the effects produced on similar quantities of blood exposed to atmospheric air; and also the effects produced on the blood of animals who have breathed the *nitrous oxide gas,* compared with the blood of those who have breathed atmospheric air, support in a very conclusive manner the doctrine I have adopted to explain the red colour of the blood.—For he observes that '*nitrous oxide gas,*' is composed of oxigene 37 parts, and nitrogene 63 parts,—" existing *perhaps* in the most intimate union which those substances are capable of assuming; for it is unalterable by those bodies which are capable of attracting oxigene from nitrous gas, and nitrous acid at common temperatures."*—He exposed two vials of venous blood, one to the nitrous oxide, and the other to atmospheric air, and found that the coagulum of the blood exposed to the nitrous oxide, was rendered darker and more purple, than the blood exposed to atmospheric air.—Also blood drawn from two animals, one who had breathed the nitrous oxide, and the other atmospheric air, and he found that the blood of the two animals assumed different colours, corresponding with the blood exposed to the two different gases, mentioned in the above experiment.—Hence the inference is, that the affinity between the oxigene and the nitrogene of the nitrous oxide, is much stronger than the affinity between the oxigene and the nitrogene of the atmospheric air; that the temperature of the blood, together with the attraction of the iron therein, being insufficient to disengage much oxigene from the nitrous oxide, consequently less heat is evolved from the partial decomposition of the nitrous oxide, than from atmospheric air in the process of respiration, therefore the iron in the blood is only oxided in an inferior degree, which accounts for the fixation of the violet coloured ray, (the easiest of refrangibility) and resolves the phenomenon of the purple colour, the blood assumes from the effects of the *nitrous oxide.* —" Likewise the blood altered by nitrous oxide gas, is capable of being again rendered vermilion by exposure to common air, or to oxigene gas."

* See Davy's Chemical Researches.

On the different colours of the metallic oxides, with an application of these principles to the Arts.

I shall now proceed to offer for your further consideration a few remarks on the different colours of the metallic oxides, with an application of these principles to the *Arts.*—When metals are oxided by means of heat, "they are converted into earthy-like powders of different colours and properties." The *oxigene gas* during calcination is absorbed by the metal, and the oxigene and the light, (constituents of oxigene gas) become fixed in the oxide according to the degree of heat employed; for the oxide assumes the violet coloured ray first, and by increasing the temperature, the violet colour is thrown off, in consequence of its being the weakest, or the most refrangible ray: in like manner some oxides assume in rotation the different colours, according to their respective refrangibilities, and they are dissipated in that ratio to the increase of heat: the red ray, the strongest and the most difficult of refrangibility, requires still a higher temperature than the other six constituent colours of light, and from its greater affinity to oxigene than the other rays of light, it is not so easily driven off, hence the red ray becomes fixed in the oxide, which constitutes its red colour, while the heat and the other six constituents of light are set at liberty: even this red ray may be driven off by increasing the heat, and then the red oxide is converted into white.—According to the experiments of Macquer, he oxided gold with a burning glass, more powerful than that of Tschirnhausen, and remarked that the oxide assumed the violet colour.—If it were possible to increase the temperature sufficient to produce the *red oxide* of gold, it appears reasonable to infer that all the intermediate coloured oxides of this metal, might be made, provided the heat could be applied in that proportion or degree to the different refrangibilities of the various colours. This doctrine is eminently supported, by the process employed to make vermilion.—If we take four ounces of sublimed sulphur and fuse it in an unglazed earthen pot, and to this add one pound of mercury, and let it be mixed with the sulphur by stiring or agitation.—When these substances have combined to a certain

degree, the mixture spontaneously takes fire, and is suffered to burn about a minute. The flame is then smothered, and the residue pulverised, which forms a *violet powder*. This powder being sublimed, affords a sublimate of a livid red colour, which when powdered, exhibits a fine red colour, known by the name of vermilion."—Here it is very obvious, that the high degree of heat, necessary to produce this sublimate, dissipated the violet colour, in consequence of its great refrangibility, and fixed the *red ray* in the oxide, which constitutes the *vermilion colour*.—To these I could add numberless facts, on the different coloured oxides of the different metals, in support of the doctrine which I have adopted, "but no more causes are necessary than are sufficient to explain the phenomena."—Hence this exposition most elegantly proves and illustrates the doctrine of Sir Isaac Newton, on the seven different rays of light, and their different refrangibilities and reflexibilities.

It must now appear very evident, that a knowledge of these principles, and an application of them to the arts, would in a very great degree assist the manufacturers, and particularly those who work in porcelain, china, glass, and in all kinds of pottery, to *burn in*, and fix the different colours, according to their *different refrangibilities*.—That is to say, the degree of heat which would be necessary to fix permanently the *red colour*, would be a temperature so high, as to burn out and dissipate, all the other colours, provided all the seven coloured oxides, were made from the same metal, and painted on a piece of porcelain; therefore to avoid an error of this kind, the manufacturer would be obliged to burn in the *red colour* first, secondly the orange, thirdly the yellow, fourthly the green, fifthly the blue, sixthly the indigo, and seventhly and lastly, the violet colour; for by an attempt to burn in and fix the violet colour first, and afterwards to burn in the red, before the latter could be accomplished, the former would be dissipated.—Therefore it is necessary to know that *the degree* of heat sufficient to produce the violet coloured oxide of gold, would be of so high a temperature as to drive off all colour from the red oxide of lead, and convert it into a white litharge: hence when several colours are to be fixed in, or burnt on porcelain at the same

time, the different coloured oxides from the different metals should be selected, which would all bear the same degree of heat.—Say 1300 degrees of Fahrenheit's thermometer, consequently no two oxides of different colours from the same metal would answer, therefore a knowledge of these principles and their application, would enable the manufacturer to adorn and beautify his wares, and to bring to greater perfection the different branches of the arts.

No. XLI.

Observations of the eclipse of the sun, June 16th, 1806; made at Lancaster, by Andrew Ellicott Esquire,

Read August 15th, 1806.

Lancaster, August 1st, 1806

DEAR SIR,

THE following observations, which I request the favour of you to hand to the Philosophical Society, were made at this place on the solar eclipse of the 16th of June last.

The morning was cloudy till about 9 o'clock, when the sun became visible through thin flying clouds: a short time before the beginning of the eclipse, the clouds were so far dissipated, that the limb of the sun was very distinct, and well defined. At $9^h\ 33'\ 8''$ A. M. apparent time, the eclipse began; the first impression made by the moon was at the point expected, and to which my eye was constantly directed.—The end of the eclipse was at $0^h\ 18'\ 56''$ P. M. apparent time.—A few minutes after the eclipse began, the clouds increased so much as to prevent any measures between the points of the cusps or horns being taken till $10^h\ 44'\ 25''$, when the following series commenced.

I.